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Original article

Preference for fixed or automatic CPAP in patients with obstructive sleep apnea syndrome

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Abstract

Background: The aims of this study were to compare compliance to treatment with fixed CPAP and with autoCPAP, subjective preference for type of CPAP treatment, and factors associated to preference for autoCPAP in patients with OSAS.

Patients and Methods: Twenty-two subjects were studied in a randomized, single blind cross-over fashion. They were treated for one month by fixed CPAP (Élite Sullivan V, ResMed, Sydney, Australia) and one month by autoCPAP (Autoset T, ResMed, Sydney, Australia).

Results: Four subjects who stated a preference for fixed CPAP and four who expressed no preference were pooled together; fourteen preferred autoCPAP. Compliance to treatment using the two machines did not differ in the first group (3.8 (1.9) vs. 3.8 (1.5) h/day, fixed vs autoCPAP), but was higher with autoCPAP in the second group (4.8 (1.8) vs 5.5 (1.5) h/day, $P < 0.05$). Baseline apnea/hypopnea index (AHI) was high in both groups, but was higher in the second group ($P < 0.02$). First treatment was always fixed CPAP in patients who preferred fixed CPAP, while it was either in the other subjects.

Conclusions: Compliance to autoCPAP differs among OSAS patients. As long as factors predicting higher compliance to autoCPAP are not found, a trial with autoCPAP in patients poorly compliant to fixed CPAP may be warranted.

Keywords: Sleep apnea; Patient compliance; Ventilatory treatment; Sleepiness; Equipment and supplies

1. Introduction

Treatment of obstructive sleep apnea syndrome (OSAS) by continuous positive airway pressure (CPAP) is well established. Candidates for CPAP treatment include subjects with moderate to severe respiratory disorders and excessive daytime sleepiness (EDS); indications for CPAP treatment in patients with mild OSAS are controversial [1,2]. Overall, less than satisfactory compliance to treatment is usually the most important limitation of CPAP effectiveness.

Automatic CPAP (autoCPAP) ventilators, compared to fixed level CPAP machines, administer a lower mean level of positive pressure during the night. This may lead to improved compliance, as the lower pressure could be easier to apply and to tolerate; high CPAP pressure levels may also be more commonly associated with side effects [3,4].

The enhancement of compliance with autoCPAP is uncertain. In previous studies compliance to treatment was not related to CPAP level [5–7], while it was related to CPAP side effects in some [5,8] but not in other investigations [7,9,10]. Among studies directly evaluating the effects of autoCPAP on compliance to treatment, a few showed a positive effect [11–14], while others did not [15–17].

Data comparing fixed and automatic CPAP treatment have mainly focused on mean ventilator use in groups of patients; inter-individual use of ventilators, and characteristics of patients who accept or preferentially use each type, have received little attention. Even if autoCPAP machines do not determine increased compliance in unselected OSAS patients, it is possible that there is a subpopulation of OSAS patients who preferentially use them [4,18,19]. In this regard, one non-cross-over study found that subjects with both stage-dependent and posture-dependent sleep apnea have a lower use of fixed and a similar use of automatic CPAP, as compared to other patients [20]. A recent

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cross-over study showed a significant but slightly higher compliance to autoCPAP in selected subjects with fixed CPAP needs pressure of ≥ 10 cm H_2O, but made no comparison to subjects needing lower CPAP levels [14].

The aims of this study were to compare: compliance to fixed and autoCPAP treatment; subjective preference for type of CPAP treatment; and associated preference factors for autoCPAP among patients with OSAS diagnosed in two Italian centres.

2. Patients and methods

Subjects referred for suspected OSAS to the Palermo National Research Council and the Bari University Sleep Respiratory Disorders Centre underwent a nocturnal polysomnography for diagnosis. Polysomnographic studies included recordings of EEG (2 unipolar leads), left and right EOG, submental EMG, oro-nasal airflow by nasal cannulas, thoracic and abdominal movements, oxyhemoglobin saturation (SaO_2), and snoring by a microphone on the sternal notch. Sleep stages were scored according to standard rules [21], and microarousals were scored according to the American Sleep Disorders Association (ASDA) recommendations [22]. Sleep efficiency was calculated as total sleep time/time in bed × 100. Apneas were identified according to usual criteria. Hypopneas were scored as discernible flow reductions followed by either SaO_2 reduction $>3\%$ or by an arousal [23]. Apnea/hypopnea index (AHI) was calculated as (number of apneas + number of hypopneas)/hour of total sleep time. OSAS was defined, according to ASDA recommendations, as an AHI >5 associated with EDS or at least two other symptoms not better explained than by sleep disordered breathing (SDB) [23]. Consecutive subjects in whom OSAS was diagnosed, with an AHI ≥ 30 and no overt cardiopulmonary disease, were requested to participate in this study. All subjects accepted. Twenty-two subjects with OSAS, 21 male and 1 female, entered the study, one half of them recruited in Palermo and one half in Bari. They complained of moderate to severe daytime sleepiness (Epworth sleepiness scale (ESS) score 16.3 (5.0)). Patients from Palermo were older than those of the Bari group (58.5 (7.5) vs 48.4 (5.8) years, respectively, $P < 0.001$), but did not differ in either body mass index (BMI) (32.1 (3.0) vs 33.7 (3.3) kg/m^2, respectively) or in ESS score (14.3 (5.1) vs 18.4 (4.2), respectively). The protocol was approved by the Institutional Scientific Committee.

Protocol. Before home treatment initiation, patients were subjected to polysomnography (PSG) during CPAP application. Methods used for the recording and analysis of PSGs were the same as for the baseline studies; pressure delivered at the nose was sampled at the mask and continuously monitored by a pressure transducer (Validyne MP45-26-871, Northridge, CA). The snoring and the flow signals controlled residual upper airway obstruction after cessation of apneas and hypopneas. CPAP was administered during PSG by an autoCPAP machine (AutoSet T, ResMed, Sydney, Australia) to determine a suitable pressure level for treatment with fixed CPAP. Optimal fixed CPAP level was that exceeded for only 5% of the night (95th percentile CPAP), unless differently suggested by the analysis of the PSG. This titration modality was used to minimize differences in criteria for choice of fixed pressure between sleep centres and to insure that the autoCPAP could satisfactorily correct sleep-breathing disorders in all patients.

All patients then received for the first month either a fixed level CPAP machine (Sullivan Élite, ResMed, Sydney, Australia) or the same autoCPAP used during PSG, followed by the alternative machine for one month. Machines were assigned in a single blind, random fashion. Patients were not informed of the different pressure modalities of the two machines. Fixed CPAP was set at the level determined during the PSG. AutoCPAP was set to freely deliver pressure levels ranging from 4 to 18 cm H_2O; the alarm for excessive leaks was disabled, and patients were instructed to perform a three-minute leak test before sleeping. Humidifiers were not used with either machine. At the end of each month BMI and ESS scores were re-evaluated and patients answered a questionnaire about sleep quality, persistence of symptoms, and side effects. At the end of the second month they were asked which machine they had preferred. Compliance data were downloaded to evaluate pattern and duration of use for each machine; in addition, data were retrieved indicating daily mean and 95th percentile pressure levels delivered by autoCPAP.

Statistical analysis was performed using StatView 4.90 for Windows (SAS Institute Inc, Cary, North Carolina, USA). Data are expressed as mean (SD) values. Comparisons between variables recorded before and after treatment were done either by paired Student's t test or by one-way analysis of variance, followed by Scheffè's test for post-hoc paired comparisons. Comparisons between variables recorded in different groups of patients were done by unpaired Student's t test. A P value <0.05 was considered as statistically significant.

3. Results

Sleep structure substantially improved with CPAP application compared to the baseline night (Table 1). AutoCPAP was effective in reducing sleep-respiratory disorders in all subjects. AHI, calculated on PSG during its application, was 6.9 (4.5) compared to 68.4 (12.1) during the baseline night ($P < 0.001$). In the baseline study, four patients (2 in each centre) showed posture-dependent sleep apnea, defined as AHI in lateral posture $<50\%$ than AHI in supine posture; none had respiratory disorders confined to NREM or REM sleep.

The 12 subjects who received fixed CPAP as first treatment did not differ from patients who received

Table 1
Sleep structure in the baseline and in the autoCPAP polysomnographic studies

		TST min	SE (%)	Stage 1 (%TST)	Stage 2 (%TST)	Stage 3–4 (%TST)	Stage REM (%TST)	Arousal index
Baseline	Mean	311.7	82.5	16.2	60.4	9.2	14.2	50.5
	SD	85.4	10.5	7.0	11.2	9.3	8.1	12.9
CPAP	Mean	300.1	80.1	11.7	45.3	21.3	22.8	8.2
	SD	81.6	12.4	7.9	19.7	15.5	11.0	4.5
P		NS	NS	<0.05	<0.001	<0.001	<0.001	<0.001

TST, total sleep time; SE, sleep efficiency.

autoCPAP as first treatment in terms of age (53.8 (8.8) vs 52.9 (8.1) yrs), BMI (33.3 (3.1) vs 32.3 (3.4) Kg/m^2), ESS score (16.6 (3.7) vs 16.0 (6.5)), AHI (68.5 (12.4) vs 68.1 (12.5)) or mean lowest oxyhemoglobin saturation (85.7 (3.8) vs 85.8 (2.8)%).

Mean use of each CPAP modality is shown in Table 2. Compliance to CPAP, whether calculated using the total period with the machine or only the days when the machine was applied, did not differ either between the first and the second month or between fixed and autoCPAP.

ESS scores of 4.7 (3.5) and 4.1 (3.1) were found after the first and second month of treatment, respectively, both values differing significantly from baseline value ($P < 0.001$) but not between each other. As for treatment modalities, ESS scores of 4.9 (3.7) and 3.9 (2.8) were found after fixed and automatic CPAP, respectively; again, these scores significantly differed from baseline value ($P < 0.001$) but not between each other.

After two months, four subjects preferred fixed CPAP as permanent treatment, fourteen autoCPAP, and four did not express any preference. Distribution of preferences was identical between Palermo and Bari centres. Two of the four subjects with posture-dependent OSA preferred fixed CPAP and two autoCPAP. Fixed CPAP was the first treatment for all four subjects who stated a preference for this modality. AutoCPAP was preferred by six subjects who began treatment with fixed CPAP and by eight who began with autoCPAP. Among the patients who did not express a preference, fixed CPAP was the first treatment in one case and autoCPAP in three. However, the effect of the first modality of treatment could not be tested statistically due to paucity of data.

Potential predictive factors for autoCPAP preference were investigated by comparing characteristics of the subjects who indicated autoCPAP preference with those of all other subjects pooled together. Among those who did not express a preference for autoCPAP, mean daily use of the machines in the total period was 3.8 (1.9) h/day for fixed CPAP and 3.8 (1.5) h/day for autoCPAP (NS). Among those who preferred autoCPAP, values were 4.8 (1.8) for fixed and 5.5 (1.5) h/day for auto ($P < 0.05$); two subjects from this group had >2 h/day difference between autoCPAP and fixed CPAP use (both having received treatment by autoCPAP in the second month). Characteristics of subjects in relation to subjective preference are shown in Table 3. No significant difference in age, BMI, or ESS scores was observed between groups, but a statistically significant higher AHI value at baseline was found among subjects who chose autoCPAP ($P < 0.02$). Fixed CPAP pressure level, mean autoCPAP pressure level, difference between these pressure levels, and 95th percentile autoCPAP pressure level did not differ significantly between groups.

Questionnaires and ESS scores revealed that reasons for subjective treatment preference were most often linked to the modality of pressure administration and more rarely to differences in side effects (usually very mild) or to perceived difference in effectiveness. All four subjects who chose fixed CPAP preferred a fixed pressure level, either because disturbed by the periodic reductions (three subjects) or occasional sharp increases in pressure (one subject who received a fixed CPAP level of 7 cm H_2O) administered by autoCPAP; only one complained of more frequent side effects with autoCPAP, while none felt that either ventilator was a more effective treatment (see Table 3 for post-treatment ESS scores). Among the fourteen subjects who preferred autoCPAP, eleven found it more comfortable, five complained of more side effects with fixed CPAP, and two experienced more improvement after autoCPAP (difference in ESS scores between fixed CPAP and autoCPAP >4). No subject mentioned any characteristic of the CPAP devices (e.g. noise) other than pressure-delivery as a reason for preference of either treatment modality.

Table 2
Mean use of each machine in the total sample of patients

	Use-total period (h/day)	Days of machine use (%)	Use-days with machine applied (h/day)
1st month	4.7 (1.8)	86.4 (16.9)	5.3 (1.4)
2nd month	4.6 (1.8)	86.3 (17.5)	5.2 (1.3)
P	NS	NS	NS
Fixed CPAP	4.4 (1.9)	83.9 (18.6)	5.1 (1.5)
Autocpap	4.9 (1.7)	88.8 (15.2)	5.4 (1.2)
P	NS	NS	NS

Values are mean (SD).

Table 3
Data collected on subject preference for each machine

	Subjectively preferred CPAP machine		
	Fixed CPAP or none	AutoCPAP	*P*
Age (yrs)	53.0 (7.6)	53.6 (9.0)	NS
AHI at baseline	60.0 (9.7)	73.1 (11.0)	<0.02
Mean lowest SaO_2 at baseline (%)	87.5 (3.3)	84.6 (3.8)	NS
Pressure with fixed CPAP (cm H_2O)	10.5 (2.0)	10.8 (1.3)	NS
Mean pressure autoCPAP (cm H_2O)	8.2 (1.6)	7.9 (1.7)	NS
Fixed-mean autoCPAP (cm H_2O)	2.3 (1.1)	2.9 (1.5)	NS
95th centile level autoCPAP (cm H_2O)	10.4 (1.4)	10.2 (1.5)	NS
ESS score at baseline	14.9 (5.3)	17.1 (4.9)	NS
ESS score after fixed CPAP	5.3 (3.3)	4.6 (3.9)	NS
ESS score after autoCPAP	4.8 (3.6)	3.4 (2.2)	NS

Values are mean (SD). ESS, Epworth sleepiness scale; AHI, apnea/hypopnea index; SaO_2, oxyhemoglobin saturation; OSA, obstructive sleep apnea.

4. Discussion

Use of two machines delivering fixed and variable CPAP resulted on average in a similar compliance to treatment, but subjective preference for, and use of, the ventilators differed among subjects. More subjects preferred autoCPAP, and more prolonged use of this machine in some cases determined a substantially higher compliance to treatment; among the other patients a similar compliance to both types of treatment was found.

Not unexpectedly, age, BMI, and degree of subjective somnolence were unrelated to subjective preference for either machine. AHI was higher in the patients who preferred autoCPAP, but the clinical relevance of differences in AHI values, such as those found in the subjects of this study, is dubious. No other factor associated with higher preference for autoCPAP could be demonstrated.

Improvement in compliance with autoCPAP may primarily be an effect of the lower average pressure due to variability during the night [17]. This has not been supported by data published so far, as no significant correlation between pressure levels and compliance to fixed or autoCPAP has been found [16]. Similarly, in this study the level of fixed pressure did not differ between patients who preferred autoCPAP and the other subjects; nor did we observe a significantly higher difference between fixed CPAP pressure level and mean autoCPAP pressure level among patients preferring autoCPAP. Pressure modality may indeed influence patients' satisfaction, but in opposite ways. In fact, some patients among those who preferred autoCPAP did indicate modality as a reason for their preference, as might be expected.

By contrast, the four patients who chose fixed CPAP considered autoCPAP pressure administration to be unpleasant. One subject (who received only 7 cm H_2O with fixed CPAP) poorly tolerated occasional pressure peaks delivered during the night by autoCPAP, supporting the traditional idea that high levels of CPAP are less well tolerated than low levels and that autoCPAP is not indicated for patients who require low pressure levels [4]. The remaining three patients disliked low pressure administration.

Due to the small number of subjects who preferred fixed CPAP, arousal indices during autoCPAP could not be statistically compared between this group and those preferring autoCPAP. Several studies have demonstrated that the high pressure levels briefly administered by autoCPAP during the night do not disrupt sleep [24–27]. Rather, pressure increases may follow arousals that, in turn, may have been induced by airway obstruction caused by a previous excessive pressure reduction [27]; this could explain the recent finding of more frequent arousals during epochs with increasing rather than with decreasing pressure [28]. Therefore, the average lower pressure delivered by autoCPAP should be considered not just as a possible factor for improving CPAP acceptability, but also as a possible source of poorer tolerance to treatment, although this seems to be the case in only a minority of cases.

Side effects of treatment, which were absent in most subjects and were mild in any case, had little weight in the choice of a machine. In the long term the development of further side effects could have more impact on compliance to treatment. However, this seems unlikely, as it has been shown that CPAP compliance tends to remain stable after the first month of treatment [7], while most studies have not indicated an influence of side effects on compliance [7,9,10].

Factors influencing compliance to fixed CPAP have been studied extensively and are still highly controversial [29,30]. Several investigations of factors such as severity of respiratory disorders, somnolence and age showed contrasting results, and the most recent studies have cited the influence of education, personality traits and support by medical staff [31–33]. It is possible that psychological factors are also important in determining preference for fixed or autoCPAP. In this respect, despite our lack of statistical support, the fact that all subjects who preferred fixed CPAP had used that machine first suggests the role of psychological factors. A larger study sample might statistically prove this hypothesis.

On the other hand, the subjects who preferred autoCPAP used it as either first or second treatment. Moreover, the two patients who showed a difference in use between the two machines >2 h/day used fixed CPAP first. These data suggest that using autoCPAP as a second modality might improve compliance, while the reverse is probably impossible. Thus, it may be advisable to begin treatment with the less expensive, fixed CPAP and then try autoCPAP if compliance is not satisfactory, independently of severity of symptoms and recommended pressure levels. If treatment is

started with autoCPAP it should be continued in the long term, as a shift to fixed CPAP may be difficult.

In conclusion, autoCPAP did not lead to a higher average compliance to ventilatory treatment in unselected patients with OSAS, even though it was considered more acceptable by most. However, some patients had a substantial increase in CPAP use when they shifted from fixed to autoCPAP, although at present such subjects cannot be identified in advance. As long as factors predicting higher compliance to autoCPAP are not clearly known, a trial with autoCPAP in patients poorly compliant to fixed CPAP may be warranted.

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